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Effective subgrid-scale parameterization for shallow water dynamics using stochastic mode reduction

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We address the question of parametrizing the subgrid scales in simulations of geophysical flows by applying stochastic mode reduction to the stochastically forced shallow-water equations. The problem is formulated in physical space by defining resolved variables as local spatial averages over finite-volume cells and unresolved variables as corresponding residuals. Based on the assumption of a time-scale separation between the slow spatial averages and the fast residuals, the stochastic mode reduction procedure is used to obtain a low-resolution model for the spatial averages alone with local stochastic subgrid-scale parametrization coupling each resolved variable only to a few neighbouring cells.
The capability of this approach is presented for the one-dimensional case. There the closure improves the results of the low-resolution model and outperforms purely empirical stochastic parametrizations (Zacharuk, M., Dolaptchiev, S.I., Achatz, U. and Timofeyev, I. 2018: Stochastic subgrid-scale parameterization for one-dimensional shallow water dynamics using stochastic mode reduction. Quart. J. Roy. Met. Soc.).
To investigate a more atmosphere like model, we apply the approach to the two-dimensional case with rotation. This allows more directions of the wave vector, and a geostrophic mode, which considerably changes the correlation function. At this step the construction of the closure conceptually remains the same. However due to dimensionality an efficient implementation needs to be applied, which exploits sparse interaction coefficients. This step is still in progress.